VELSICOL
HARDEMAN COUNTY LANDFILL
SUPERFUND SITE

FIVE-YEAR REVIEW

SEPTEMBER 25, 2000

U.S. Environmental Protection Agency
Region IV

VELSICOL HARDEMAN COUNTY LANDFILL
FIVE-YEAR REVIEW SIGNATURE COVER

SITE NAME, LOCATION, AND EPA ID

Velsicol/Hardeman County Landfill
Toone-Teague Road
Toone, Tennessee

TND980559033

SITE STATUS

The Velsicol/Hardeman County Landfill was finalized on the National Priorities List in 1982. The remedy is complete. The Site was a PRP-lead RI/FS and is a PRP-lead RD/RA. The Site was used as a landfill to dispose of waste from Velsicol's Memphis Tennessee Plant Site. The landfilling operation commenced in October 1964 and continued until June 1973. The waste had been disposed of in three specific areas which covered approximately 27 acres.

The RA for OU#1 consisted of constructing a groundwater extraction and treatment system comprised of nine groundwater extraction wells, force main piping, and a groundwater treatment plant designed to treat up to 525 gallons of groundwater per minute. The groundwater extraction and treatment system has been fully operational since November 1997. The Remedial Action for OU#2 consisted of constructing a RCRA composite cap to minimize surface water infiltration. Construction of the cap was completed in October 1996.

REVIEW STATUS

The Five-Year Review conducted at the Velsicol Hardeman County Landfill Site is required by statute. Treatment is ongoing, and hazardous substances are still present on Site at concentrations above protective levels for unrestricted exposure and unlimited use. When the remedial action is complete, hazardous substances will remain on-site above levels that allow for unlimited use and unrestricted exposure. The Remedial Action mobilization date, June 30, 1995, is considered the "trigger" for this five-year review. The next Five-Year Review will be required in 2005, five years from the completion date (i.e., signature date) of this Five-Year Review Report.

RECOMMENDATIONS AND REQUIRED ACTIONS

The Performance Evaluation should be implemented in 2000 to provide data to further assess the adequacy of the flow rates and capture zone; whether contaminants are decreasing as needed; whether containment is effective; and what actions could enhance the rate of natural degradation.

PROTECTIVENESS STATEMENT

The remedy implemented at the Velsicol Hardeman County Landfill Site is protective of human health and the environment. Results of the Five-Year Review indicate that:

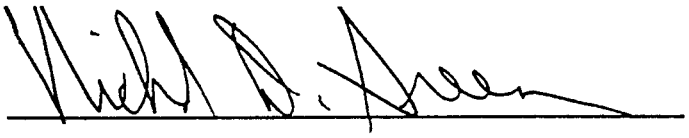
- Mass removal is ongoing and mass reduction has occurred since the system was installed. Approximately 53,548 pounds of carbon tetrachloride, 12,421 pounds of chloroform, and 1,601 pounds of methylene chloride have been removed from groundwater.

- The current site controls are adequate. The entire 240-acre Site is secured against unrestricted access by a perimeter fence. Access points are controlled by locked gates. Signs are posted along the fence at access points denoting "Closed - Hazardous Waste Landfill - Access Prohibited."

Conditions at the Site are not expected to change in the near future, given the area's land use (agriculture, forestry, recreation). Notifications were placed on property deeds that were effected by Site contamination. The restriction precludes the placement of potable wells within the area of groundwater contamination.

9/29/00

Date



Richard D. Green
Waste Management Division Director

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) Region 4 has conducted a five-year review of the remedial actions implemented at the Velsicol Chemical Corporation (Hardeman County) Landfill site located near Toone, Hardeman County, Tennessee. This review was conducted during June 2000. This report documents the results of the review.

The purpose of five-year reviews is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify deficiencies found during the review, if any, and recommendations to address them.

This review is required by statute. EPA must implement five-year reviews consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA Section 121(c), as amended, states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented*

The NCP part 300.430 (f)(4)(ii) of the Code of Federal Regulations (CFR) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted*

exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

This is the first five-year review for the Velsicol Chemical Corporation (Hardeman County) Landfill (Site). The triggering action for this statutory review is the date of on-Site construction for Operable Unit No. 1 (OU#1).

EPA has established four types of five-year reviews (I, Ia, II, and III). This allows reviews to be tailored to the status of site activities and site-specific considerations. A type I review is the lowest level of evaluation of protectiveness, and is appropriate for completed sites. A type Ia review is a modified version of a type I review, and is appropriate for active sites, a type II review is the intermediate level, and a type III review is the highest level. The five-year review for this Site is a type Ia review. The tasks to be performed under a type Ia review include document review and a written report. A site visit and ARAR review is not required for type Ia ongoing sites contrasted with the more extensive requirements at type I completed sites.

2.0 SITE BACKGROUND

In 1963, Velsicol Chemical Corporation (Velsicol) purchased 242-acres of land in Hardeman County, Tennessee to dispose waste from its pesticide manufacturing plant in Memphis, Tennessee. The Site is bounded to the east by the Pugh Creek, and to the north and south by forest, and to the west by Toone-Teague Road (also known as Old Toone Road).

The landfill consisted of a series of excavated trenches along ridge tops in 3 areas (the north, middle, and south areas), encompassing approximately 27 acres. The trenches were excavated approximately 12 to 15 feet deep, 10 to 12 feet wide, 200 to 500 feet long, and were placed approximately 4 to 8 feet apart. Drums and cardboard boxes were disposed at the Site containing heptachlor catalyst, fiber drums, IPA still D-30 bottoms, acetic acid bottoms, R-2 bottoms, chlorendic anhydride still bottoms, PCL bottoms J-11, carbon beds, and bandane filter cake. A daily cover was placed using the soil excavated for the trenches. After a trench was filled, a three-foot soil cover was placed, graded to promote surface water drainage, and compacted with a bulldozer.

Reports of possible groundwater contamination from local residents were received in 1977, prompting an investigation of the water bearing units beneath the Site. By late 1978, investigations confirmed groundwater contamination had impacted the residential wells near the Site. In early 1979, Velsicol provided an alternative potable water supply to the 26 residences located adjacent to the disposal area within a one-mile radius, and plumbing fixtures, household appliances, and cookware were replaced (CRA, 1991).

In March 1980, the Tennessee Department of Health and Environment (TDHE) and Velsicol agreed to construct a low permeability clay cap over the disposal areas to minimize surface water infiltration and additional environmental impact. Groundwater, surface water, and sediment monitoring programs were implemented and lysimeters were installed beneath the disposal areas to assess the

effectiveness of the cap. Groundwater, surface water and sediment monitoring identified the presence of volatile organic compounds, predominantly carbon tetrachloride and chloroform.

In July 1986, a Site Enforcement Agreement was signed between EPA and the State. This agreement stipulated that the TDHE would issue a Commissioner's Order to Velsicol to conduct a Remedial Investigation and Feasibility Study (RI/FS) at the Site. On January 7, 1987, TDHE issued the Commissioner's Order. In February 1989, the EPA became the lead agency and entered into an Administrative Order on Consent (AOC) with Velsicol to complete the RI/FS. The RI/FS was completed in March 1991. After reviewing the results of the RI/FS, the EPA divided the Site into two operable units; Operable Unit One (OU#1) addresses groundwater contamination and Operable Unit Two (OU#2) addresses the landfill or "source" (the buried wastes and associated contaminated soils).

2.1 Chronology of Events

The following table is a chronology of events related to the Site investigation at the Hardeman County Landfill Site.

Table 1
Chronology of Events

Site Discovery	June 1, 1981
Hazard Ranking System Package	December 1, 1982
Proposal to National Priorities List (NPL)	December 30, 1982
Final on NPL	September 8, 1983
Preliminary Assessment/Site Investigations	January 1, 1984

Table 1
Chronology of Events

Consent Decree (CD) Filed	February 17, 1989
Remedial Investigation/Feasibility Study (RI/FS) start	February 17,1989 November 4, 1991
RI/FS Complete	June 27, 1991 June 7, 1995
Record of Decision (ROD) for OU#1	June 27, 1991
Unilateral Administrative Order (UAO) for OU#1	October 18, 1991
Remedial Action (RA) Construction Start for OU#1	June 30, 1995
Execution of Record of Decision (ROD) for OU#2	September 26, 1995
Unilateral Administrative Order (UAO) for OU#2	December 22, 1995
Remedial Action (RA) Construction Start for OU#2	May 26, 1997
Final Construction Inspection of OU#1	October 1997
Final Construction Inspection of OU#2	October 1997
Implementation of Groundwater Monitoring Program	December 2, 1997
Preliminary Closeout Report (PCOR)	August 13, 1998
Operations & Maintenance Plan	November 1999
Performance Standards Verification Plan	November 1999
Performance Evaluation Plan	April 2000
Five-Year Review	June 30, 2000

3.0 REMEDIAL ACTIONS

OU#1 Record of Decision

A Record of Decision (ROD) was issued on June 27, 1991 for OU#1. The remedial action objectives include:

- controlling exposure to the contaminated groundwater; and
- controlling migration of contamination through groundwater to soils, sediments and surface water bodies.

The OU#1 Record of Decision identified the following as major components of the remedy :

- Install and maintain approximately five extraction wells along the northern boundary of the disposal areas located within the Site developing a hydraulic gradient to prevent groundwater contamination above Groundwater Remediation Levels from leaving the disposal area.

- Install and maintain approximately ten extraction wells into the off-Site groundwater contamination plume to control the groundwater contaminant migration and remediate the groundwater off-Site to Groundwater Remediation Levels.

- Build and operate a groundwater treatment system for the removal of contaminants from the extracted groundwater to National Pollutant Discharge Elimination System (NPDES) requirements prior to the water being discharged to a nearby surface water body. The groundwater treatment is expected to be performed using, at a minimum, settling tanks for precipitation of dissolved solids, an air striper and a carbon adsorption system.

- Monitor groundwater contaminant levels to verify that remediation goals are achieved.

- Impose groundwater use restrictions for the affected area and post appropriate hazardous waste disposal signs and around the Site.

- Maintain the disposal area including the fences and soil cover.

- Identify and evaluate possible additional remedial actions (operable units) required for addressing the contamination of the entire site including the contaminant source (the disposal areas) and environmental/ecological concerns.

Groundwater Remediation Levels

Contaminants of Concern	***Groundwater Remediation Level (mg/l)***[1]	***Range of Positive Detections (mg/l)***[2]
Acetone	0.7[3]	0.0169 ... 10.1
Carbon Tetrachloride	.005	0.00632 ... 64.0
Chlorobenzene	0.1	0.229
Chloroform	.006[4]	2.647
Methylene Chloride	.005	0.0053 ... 0.98
Tetrachloroethene	.005	0.0155
Toluene	1.0	0.1638
Xylenes	10.0	0.0155 ... 0.0295
Bis (2-ethylhexyl)ppthalate	.004	0.0158 ... 0.580
Di-n-butyl phthalate	0.7[3]	0.011 ... 0.048
Di-n-octyl phthalate	0.14[3]	0.045 ... 0.105
2,4 - Dichlorophenol	0.1[3]	0.01412 ... 0.18
Endrin	.0002	0.00014
Endrin Aldehyde	.0002	0 .00017 ... 0.00022

Contaminants of Concern	*Groundwater Remediation Level (mg/l)*[1]	*Range of Positive Detections (mg/l)*[2]
Endrin Ketone	.0002	0.00014 ... 0.0037
Heptachlor	.0004	0.00011

Note:
(1) Values from OU#1 ROD; MCL unless otherwise noted.
(2) Values taken from Final Design Report, Table 3.3.
(3) Lifetime Health Advisory.
(4) Level set for a lifetime risk (70 years) of 10^{-6}.

A Unilateral Administrative Order (UAO) was issued to Velsicol and NWI Land Management Corporation (NWI) to conduct the RD/RA for OU#1 on October 17, 1991 (the Order was effective November 29, 1991). The Respondent's Project Coordinator during the RD/RA was the Memphis Environmental Center (MEC) of Memphis, Tennessee and the remedial design engineer was Conestoga-Rovers and Associates (CRA) of Waterloo, Ontario. Construction of the groundwater extraction and treatment system began in June 1995 by installing extraction wells.

OU#2 Record of Decision

In addition to conducting the RD/RA for OU#1, Velsicol was required to conduct a FS for the landfill area operable unit (OU#2). Velsicol and EPA negotiated a First Amendment to the February 17, 1989 RI/FS Consent Order (First Amendment) to address the OU#2 FS. The First Amendment was effective November 4, 1991.

The purpose of the OU#2 FS was to develop and evaluate additional potential remedial action alternatives for remediating the source of the contamination (the wastes in the disposal areas) at the Site. The OU#2 FS was completed in June 1995 and the OU#2 Record of Decision was signed September 26, 1995. The remedial action objectives for the waste disposal areas include:

- prevent human exposure through direct contact or ingestion of landfill wastes or soils; and

- prevent further degradation of groundwater beneath and downgradient of the waste disposal areas.

The OU#2 Record of Decision selected the remedy of capping the approximately 27-acre landfill with a RCRA composite cap. Computer modeling results of the RCRA cap demonstrated that this technology would met the Soil Action Levels for groundwater protection. The RCRA composite cap as defined in the ROD would consist of:

- scarifying existing vegetative cover and recompacting;
- a 40-mil HDPE synthetic liner or equivalent, placed over the recompacted clay surface;
- a sand drainage blanket with a minimum hydraulic conductivity of 1 x 10-3 cm/sec placed over the liner to provide lateral drainage;
- the sand will be covered with a filter fabric and a layer of common fill and topsoil;
- a vegetative cover will be established to prevent erosion of the fill and topsoil materials; and;
- routine monitoring of the RCRA cap in order to maintain the integrity of the cap.

The Unilateral Order that required Velsicol to conduct RD/RA for the landfill cap was effective January 8, 1996.

The primary mechanism by which contaminants have been released to the groundwater is by the percolation of precipitation through the waste disposal areas. Soluble contaminants were dissolved by the infiltrating waters and have migrated through the unsaturated zone to the water table. A computer model was used to determine whether the 1980 clay cap was minimizing the leaching of wastes by infiltration. The following table demonstrates that under the 1980 cap infiltration scenario, contaminant concentrations within the waste and soil exceeded the Soil Action Levels which must

be met to be protective of groundwater.

Soil Action Levels for Groundwater Protection

Contaminants	***Average Contaminant Concentrations***		***Soil Action Levels***	
	Waste (1) (mg/kg)	*Soil (2) (mg/kg)*	*Waste (1) (mg/kg)*	*Soil (2) (mg/kg)*
Acetone	0.0	*9.6	NA	0.5428
Carbon Tetrachloride	*216.1	*15.5	1.1205	1.0543
Chloroform	*78.7	*1.8	0.8031	0.1919
Methylene Chloride	*100.4	*0.2	0.8031	0.0391
Tetrachloroethene	*9.8	*1.6	5.9389	0.6676
2,4-Dichlorophenol	*18,302.8	*68.5	99.5202	29.1442
Hexachlorobenzene	*193.9	11.6	113.1280	NA
Endrin	55.1	*23.5	NA	18.5302
Endrin Aldehyde	2.9	*18.6	NA	0.31.51
Endrin Ketone	83.2	*6.4	NA	2.0968

Note:

* Exceedance of Soil Action Levels
(1) Values taken from FS-Appendix C, Table C.8.
(2) Values taken from FS-Appendix C, Table C.5.
NA Not Applicable, no exccedance of soil action levels.

3.1 Description of Remedial Actions

OU#1

The OU#1 Remedial Action consists of five extraction wells immediately downgradient of the landfill to effectively contain the contamination source and prevent further degradation of the groundwater downgradient of the landfill, and four extraction wells in the plume to remove contaminant mass from the plume. The extracted water [a design total of 465 gallons per minute (gpm)] is pumped to a treatment plant near the northeast corner of the landfill. The treated water is surface discharged to a tributary of Pugh Creek. Figures 1 and 2 illustrate the groundwater extraction system and treatment system process.

The subsystems included within the extraction and treatment systems are as follows:

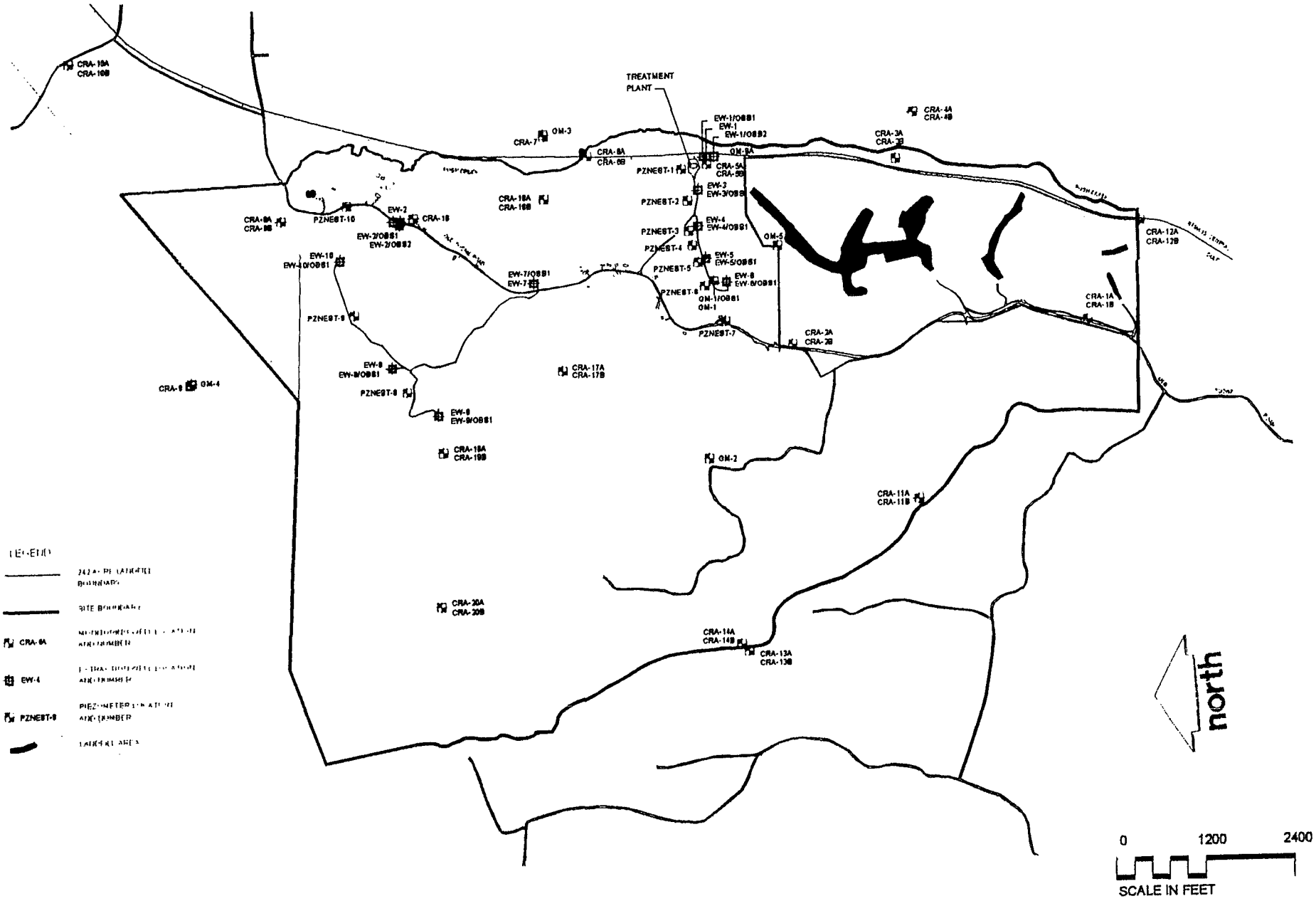
i. Groundwater Extraction Subsystem

Five groundwater extraction wells provide containment of groundwater immediately downgradient of the landfill area; four groundwater extraction wells reduce levels of groundwater contaminants in the high concentration areas downgradient of the Site; and a piping and metering system transfers groundwater to the on-Site treatment facility.

ii Groundwater Treatment Subsystem

The groundwater treatment subsystem is comprised of the following unit operations:

a. equalization tank;
b. packed column air strippers;
c. liquid phase GAC units;
d. liquid phase GAC backwash and sludge removal equipment;
e. compressed air supply unit;
f. vapor phase GAC with on-Site steam regeneration; and
g. extraction well chlorination equipment.


TREATMENT PLANT
CRA-19A
CRA-19B
CRA-7
GM-3
CRA-8A
CRA-8B
PZNEST-1
EW-1/OBS1
EW-1
EW-1/OBS2
GM-5A
CRA-5A
CRA-5B
CRA-4A
CRA-4B
CRA-3A
CRA-3B
EW-3
EW-3/OBS1
PZNEST-2
CRA-18A
CRA-18B
CRA-9A
CRA-9B
PZNEST-10
EW-2
CRA-10
EW-2/OBS1
EW-2/OBS2
PZNEST-3
EW-4
EW-4/OBS1
GM-5
CRA-12A
CRA-12B
PZNEST-4
EW-10
EW-10/OBS1
EW-5
EW-5/OBS1
PZNEST-5
EW-7/OBS1
EW-7
EW-8
EW-8/OBS1
PZNEST-6
GM-1/OBS1
GM-1
CRA-1A
CRA-1B
PZNEST-9
PZNEST-7
CRA-2A
CRA-2B
CRA-6
GM-4
EW-9
EW-9/OBS1
CRA-17A
CRA-17B
PZNEST-8
EW-6
EW-6/OBS1
CRA-16A
CRA-16B
GM-2
CRA-11A
CRA-11B
CRA-20A
CRA-20B
CRA-14A
CRA-14B
CRA-13A
CRA-13B
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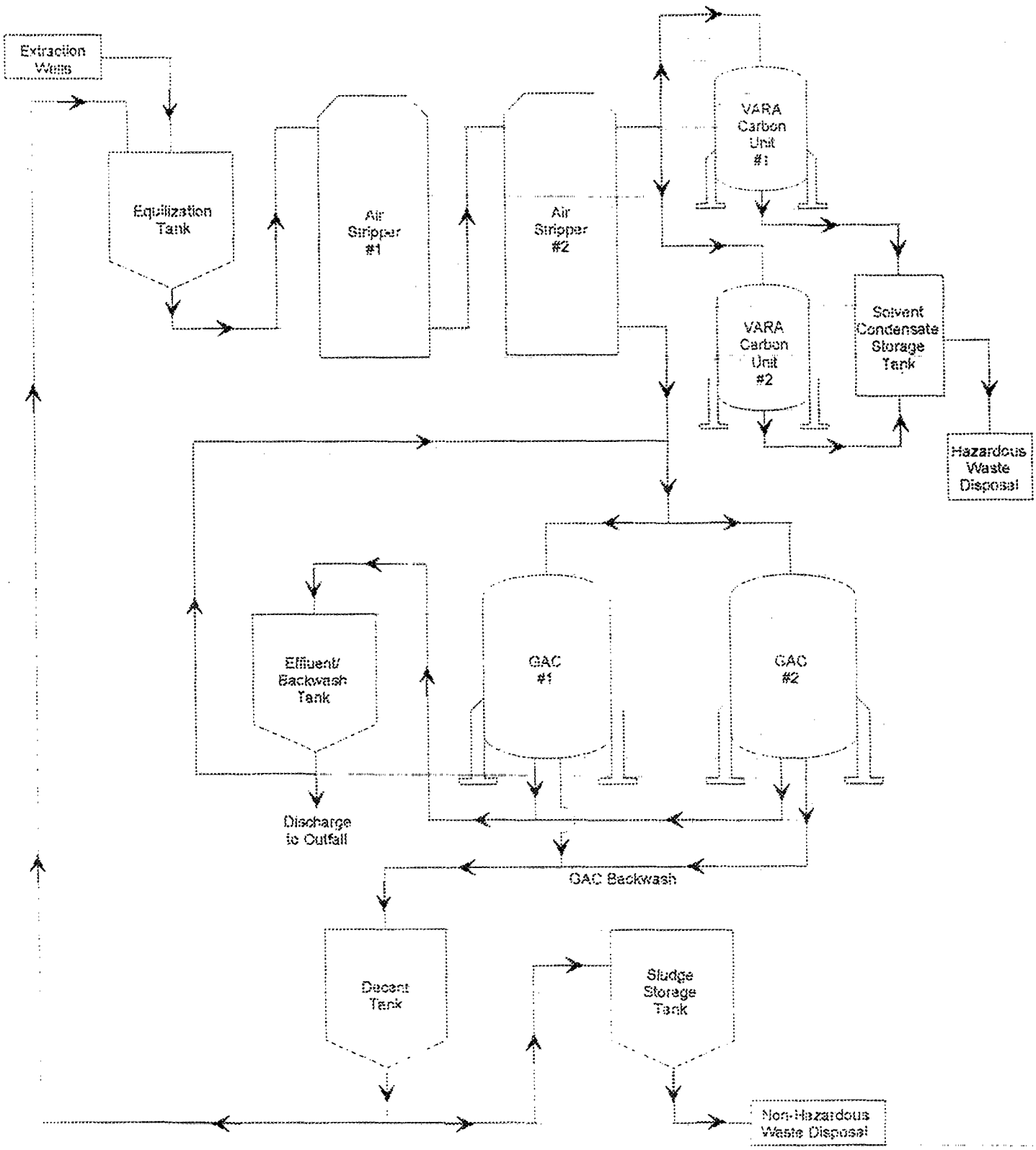
2400
SCALE IN FEET



Treatment System Process Flow Diagram

During normal operation of the groundwater treatment subsystem, approximately 420 gpm can be input from the groundwater extraction subsystem. The treatment subsystem was designed for normal operating capacity of 465 gpm, however, due to the reduced capacity of the aquifer at two extraction wells, the groundwater extraction subsystem expected flow rate is the stated 420 gpm. Hydraulic monitoring during 1997 of the aquifer determined that the reduced pumping rates at the two wells are acceptable in terms of hydraulic influence. The treatment plant has a maximum capacity of 525 gpm.

iii. Treated Water Discharge Subsystem

After water has passed through the GAC units, it flows through the backwash storage tank and is ready for discharge. Samples are obtained continuously from the backwash storage tank and analyzed for pH and metals. The samples are obtained by an auto storage tank and analyzed for pH and metals. The samples are obtained by an auto composite sampler which is capable of analyzing pH and storing the results in a data memory. A composite water sample is obtained from the auto composite sampler once each week and sent for laboratory analysis for TAL metals. The storage tank is equipped with an overflow which directs treated water into a sump. The sump is connected to a rip rap lined drainage swale through a series of manholes and 12-inch diameter drain pipe. The water is conveyed through the drainage swale to Pugh Creek.

iv. Treatment Facility Enclosure Subsystem

The process equipment is located within a 60-foot by 90-foot pre-engineered steel structure. The structure is erected on a concrete floating slab foundation. Rooms located within the facility are defined by concrete block walls.

A security system is located at the treatment facility and is tied into the Remote Operations Controller (ROC) and auto dialer system. The treatment system is surrounded by an 8-foot

high, 2-inch weave chain-link security fence.

v. Groundwater Chlorination Subsystem

A chlorination was installed as a modification to the extraction systems for the purpose of disinfecting the extraction well system on a continuous basis. Chlorinated water is distributed through an underground pipeline network to all the well locations.

Modifications to OU#1 Remedy

The objective of the plume extraction system as stated in the ROD is to restore the aquifer beyond the point of compliance to acceptable drinking water standards by removing contaminant mass from the most highly contaminated portions of the unconfined aquifer north of the disposal area. The hydrogeologic analysis indicated that four extraction wells pumping at a combined flow rate of 260 gpm will provide collection of the contaminated groundwater.

Settling tanks were not used for precipitation of dissolved solids due to particle size distribution and quantity of solids. Filtration was considered a better process. The possibility of pretreatment using multi-media sand filtration (proposed at the 30% design stage) was considered. It was decided to rely on the 1994 sampling results and remove pretreatment from the design. Fouling did become a problem during operation in 1996 and 1997. Modifications to the existing process flow through GAC vessels is being considered as a means for compensating for the solids in the process water.

O&M Evaluation

The treatment plant began operating in February 1996. During 1996 and 1997 the extraction and treatment systems were not operating at fully capacity due primarily to hydraulic limitations caused by biological fouling attributed to iron bacteria. A pilot study was initiated in March 1997 to determine the effectiveness of using chlorine to inhibit bacterial growth in the extraction wells and the treatment plant. Based on the results of the pilot scale work , modifications to the treatment

system were performed during the Fall of 1997 in order to install a full-scale chlorination system. The extraction wells were swabbed and cleaned to remove sludge and slime build up on the well casings and screens, resulting from the iron bacteria. A sodium hypochlorite injection system was retrofitted to each extraction well to administer the disinfectant to discourage biological growth and maximize extraction rates. The treatment system resumed operation in October 1997.

The sampling frequencies, sampling parameters, and reporting requirements for monitoring wells, extraction wells, source containment wells, and plume reduction wells are specified in the Performance Standards and Verification Plan (PSVP). The performance of the extraction and treatment system is assessed by means of the following data sets:

- treatment plant discharge analytical data
- bioassay using discharge water;
- groundwater hydraulic data;
- groundwater analytical data;
- treatment component analytical data; and
- flow data

Discharge Analytical Data and Bioassays

The discharge analytical data and bioassay testing is submitted to the Tennessee Department of Environment and Conservation (TDEC) State Water Pollution Control Division and copies are forwarded to EPA. NPDES discharge monitoring requirements were stipulated by the State in a letter addressed to EPA dated June 4, 1996 and an addendum dated December 2, 1997. The addendum was issued for the purpose of providing chlorine effluent limitations and monitoring requirements to coincide with the operation of the chlorination system. Table 3-1 illustrates the treatment plant discharge criteria.

TABLE 3-1

HARDEMAN COUNTY LANDFILL
TREATMENT PLANT DISCHARGE CRITERIA

Parameter	Monthly Average Concentration (mg/L)	Maximum Concentration (mg/L)
pH (std. Units)	6.0-9.0	6.0-9.0
CBOD (mg/L)	20.0	30
TSS (mg/L)	-	40
Ammonia (mg/L)	0.13	0.25
Metals (total)	**(mg/L)**	**(mg/L)**
Aluminum	0.098	1.006
Arsenic	0.003	0.006
Chlorine, Total Residual	0.015	0.026
Chromium	0.113	0.226
Copper	0.011	0.015
Iron	1.134	2.503
Lead	0.0033	0.102
Mercury	.000014*	0.000676*
Nickel	0.127	1.36
Selenium	0.005	0.026
Silver	-	0.0004*
Zinc	0.127	0.141
Volatile Organic Compounds	**(mg/L)**	**(mg/L)**
Carbon Tetrachloride	0.101	0.203
Chloroform	10.84	21.68
Pesticides	**(mg/L)**	**(mg/L)**
4,4-DDE	0.0000032*	0.0000064*
a-Endosulfan	0.0001	0.0027
Aldrin	0.0000136*	0.0000272*
b-Endosulfan	0.0000026*	0.0000064*
Cyclopentadiene	0.000077	0.0003
Dieldrin	0.000077	0.0003
Endrin	0.0000031*	0.00024
g-BHL Lindane	0.0000048*	0.0000096*
Heptachlor	0.0000025*	0.000005*
Heptachlor Epoxide	nd	-

Source: Tennessee Dept. of Environment & Conservation (June 1996 and December 1997)

From 1996 to 1999, the effluent was monitored for chemical parameters weekly. EPA and TDEC approved of reducing the chemical monitoring frequency to monthly beginning in January 2000. Biological monitoring is conducted by exposing *Ceriodaphnia Dubia* and *Pimephales promelas* to various effluent concentrations. From 1997 to 1999, biological monitoring was conducted quarterly. EPA and TDEC approved of reducing the biological monitoring frequency to semi-annually beginning the first quarter of 2000.

The State stipulates weekly monitoring and analyses of a list of general chemistry parameters, metals, pesticides, and two volatiles (carbon tetrachloride and chloroform). Daily monitoring is performed for pH and chlorine

Groundwater Hydraulic, Analytical and Flow Data

Groundwater monitoring is conducted to evaluate the groundwater quality during operation of the treatment system. The extraction wells are sampled annually to monitor the concentration reduction of the Site contaminants of concern.

The original estimated flow rate specified in the ROD was 550 gpm. In 1999, the average flow rate of the system was 305 gpm. The differences between the flow rates may result from the assumption that artesian conditions existed in the vicinity of the plume extraction wells. Prior to active extraction, an observation well located near extraction well EW-10 exhibited artesian characteristics. Since 1998, the groundwater elevations near EW-10 have decreased from artesian (+338.53 ft. MSL) to approximately 338.77 ft. MSL. Similarly, groundwater elevations at EW-8 have decreased from 381.50 ft. MSL to 356.05 ft. MSL, and elevations at EW-9 have decreased from 384.03 ft. MSL to 347.24 ft. MSL. since 1998. Tables 3-2 and 3-3 provide flow rates and mass removal rates.

TABLE 3-2

HARDEMAN COUNTY LANDFILL
HISTORICAL MONTHLY FLOW SUMMARY

Month	1998				1999			
	Total Flow (MG)*	No. of Days of Operation	Daily Flow		Total Flow (MG)*	No. of Days of Operation	Daily Flow	
			Average (mgd)	Maximum (mgd)			Average (mgd)	Maximum (mgd)
January	6.4	31	0.206	0.334	9.4	21	0.449	0.563
February	6.2	28	0.221	0.332	12.6	28	0.451	0.589
March	6.2	31	0.200	0.332	13.2	28	0.473	0.564
April	5.9	30	0.197	0.324	15.2	29	0.523	0.589
May	12.1	31	0.390	0.587	9.2	30	0.307	0.343
June	11.8	30	0.393	0.556	10.3	26	0.398	0.565
July	11.4	28	0.407	0.535	14.4	31	0.463	0.670
August	11.4	31	0.368	0.561	13.5	28	0.480	0.565
September	4.8	25	0.192	0.528	12.8	30	0.426	0.565
October	12.0	28	0.429	0.530	13.1	31	0.421	0.487
November	8.1	24	0.338	0.562	9.6	25	0.384	0.479
December	13.9	31	0.448	0.563	10.7	23	0.463	0.504
Total	**110.2**	**348**	**0.317**	**0.587**	**144.0**	**330**	**0.437**	**0.670**

*MG - Total gallons in million gallons.

TABLE 3-3

HARDEMAN COUNTY LANDFILL
EXTRACTION RATES AND MASS REMOVAL

Well I.D.	Extraction Rates		1999 Mass Removal (lbs.)
	Design (gpm)	Average (gpm)	
EW-1	5-25	20	1,339
EW-3	10-50	25	1,294
EW-4	10-50	20	959
EW-5	30-80	52	2,900
EW-6	10-50	25	1,517
EW-7	60-110	93	5,154
EW-8	70-120	66	4,908
EW-9	60-110	50	2,231
EW-10	40-90	35	2,008
Total Mass Removal			**22,311**

An evaluation of the groundwater extraction and treatment system performance is scheduled to be completed in 2000. The purposes of the evaluation are to:

- Evaluate the concentrations of the Site contaminants of concern in the deep sand unit beneath the Site;

- Evaluate the natural attenuation processes and determine the effects on the Site contaminants of concern; and

- Evaluate the capture zones in the shallow and deep sand units.

Treatment Component and Analytical Data

The plant is supervised by a full-time plant operator that performs routine maintenance of the extraction well system and treatment plant. The treatment system is controlled by four Remote Operating Controls (ROCs) that are accessed from the monitoring station in the treatment plant. The plant operator can access the treatment system through a dialup modem. This interface allows the plant operator to monitor and operate the system remotely. The ROCs monitor the individual well flow rates. The status of pumps and levels in tanks are also monitored. Two smaller ROCs are provided at the plume well sites, one at EW-7 (ROC #4) and the other at the M1 pit, which houses the controls for EW8, EW9, and EW-10 (ROC #3). The treatment system is equipped with an alarm and autodialer to notify the treatment plant operator of any unscheduled plant shutdown.

Routine maintenance of the extraction wells consists of swabbing and cleaning the wells, pumps, and associated piping. Routine maintenance of the treatment plant includes greasing pumps and motors, replacing worn components, acid washing the air strippers, disposing solvent condensate from the VARA system, replacing the carbon in the liquid phase carbon units with virgin activated carbon, and disposing solids (predominantly carbon fines) resulting from backwashing the liquid phase carbon units**.** Tables 3-4 and 3-5 provide the routine and unscheduled maintenance activities performed in 1999.

TABLE 3-4

HARDEMAN COUNTY LANDFILL
ROUTINE TREATMENT SYSTEM MAINTENANCE & DOWN TIME

Date	Length of Downtime	Description of Maintenance & Activities
January 11-12, 1999	2 days	Routine cleaning/swabbing of extraction well pumps, risers and forcemai
March 24-27, 1999	3 days	Routine acid washing of the air strippers
June 25-28, 1999	3 days	Routine acid washing of the air strippers
June 30, 1999**	1 day	Spent carbon in GAC units exchanged
November 9-11, 1999	3 days	Routine acid washing of the air strippers
December 1-7, 1999	6 days	Routine cleaning/swabbing of extraction well pumps, risers, and forcemains, pump replacement - source wells*
December 14-15, 1999	2 days	Routine cleaning/swabbing of extraction well pumps, risers, and forcemains, pump replacement - plume wells*

* Routine extraction well cleaning included steam cleaning pumps and risers.

TABLE 3-5

HARDEMAN COUNTY LANDFILL
UNSCHEDULED TREATMENT SYSTEM MAINTENANCE & DOWN TIME

Date	Length of Downtime	Description of Maintenance & Activities
January 18-19, 1999	2 days	Lightening strike required that ROC no. 1 be reprogrammed
January 21-28, 1999	6 days	Lightening strike disabled several input/output modules on ROC no. 1
April 4, 1999	1 day	Thunderstorms and power outage shutdown plant
May 31, 1999	1 day	Plant shutdown, likely due to power surge
August 7, 1999	3 days	Air stripper transducer failed requiring replacement
November 2, 1999	2 days	Air compressor repair

OU#2

The OU#2 Remedial Action upgraded the existing low-permeability clay cap to futher reduce infiltration of water into the landfill. The upgraded cap affected 24 acres of the existing 35-acre clay cap and was implemented as follows:

i. removal of existing top soil to expose the top surface of the clay cap;
ii. placement of a 40-mil LDPE liner over the clay cap;
iii. placement of a drainage net over the LDPE liner;
iv. placement of 12-inches of cover soil and 6-inches of top soil to protect the liner; and
v. application of seed to secure the cover soil with vegetation.

Modifications to OU#2 Remedy

The limit of waste was defined by an electromagnetic (EM) survey conducted in June 1996. The purpose of the EM survey was to investigate each of the three landfill areas in order to determine the limit of buried waste relative to the existing clay cap. In most areas, the LDPE extends more than 10 feet beyond the limits of waste defined by the EM survey. The upgraded cap affected 24 acres of the existing 35-acre cap.

A low-density polyethylene (LDPE) liner was used in lieu of the HDPE stipulated in the ROD due to the greater flexibility and handling ease of the LDPE. With respect to other features such as strength, permeability, ultraviolet resistance and cost, LDPE is similar or identical to HDPE.

A synthetic drainage layer (geonet) composited with geofabric was used in place of the sand drainage layer and filter fabric based on the lateral drainage requirements necessary to limit the drainage head accumulation over the LDPE. Design analysis showed that the sand was not suitable for the shallow landfill profile.

A geosynthetic clay liner was installed in areas where the existing clay cap was partially removed to permit the installation of toe drains.

The existing topsoil layer was removed and reused instead of being scarified and overlain with clay. Economically, it was advantageous to reuse the existing topsoil rather than import new topsoil.

O&M Evaluation

The treatment plant operator conducts monthly inspections of the cap to ensure that the cap integrity is not compromised, and the landfill areas are mowed as needed. The well-established vegetative layer prevents erosion from occurring.

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3.4 Remedy Implementation and Performance

Site Controls

Land use in the area is primarily agriculture, forestry, and recreation. The region of the county near the Site is sparsely populated with people and may be regarded as wilderness, farmland and wetlands, with dense forests supporting many indigenous species of wildlife. Future land use is expected to remain the same.

The current site controls are adequate. The entire 240-acre Site is secured against unrestricted access by a perimeter wire fence. Access points to the Site are controlled by locked gates. Signs are posted along the fence and at access points denoting "Closed - Hazardous Waste Landfill - Access Prohibited."

Velsicol coordinated with the State Attorney General to place notifications on property deeds that were effected by Site contamination. The restriction precludes the placement of potable wells within the area of groundwater contamination.

Remedy Performance and Optimization

Since the treatment system began fully operating in 1997, approximately 434.8 million gallons of groundwater have been extracted, removing approximately 53,548 pounds of carbon tetrachloride, 12.421 pounds of chloroform, and 1,601 pounds of methylene chloride. The extraction system will be evaluated in the Fall of 2000 as defined in the Performance Evaluation Plan. Data will be collected to determine the adequacy of the flow rates and capture zone; whether contaminants are decreasing as needed; whether containment is effective; and what actions could enhance the rate of natural degradation.

Early Indicators of Potential Remedy Failure

No early indicators of potential remedy failure (e.g., equipment breakdowns) or changes in the

scope of operations have been indentified.

O&M Costs

EPA estimated that annual O&M costs would be approximately $696,000. The annual O&M costs for 2000 are estimated between $600,000 to $615,000.

3.5 FIVE-YEAR REVIEW FINDINGS

Documents Reviewed

The five-year review was conducted by Beth Walden, EPA Remedial Project Manager for the Site. The review began with a document review of the Consent Decree, RI/FS, RODs, UAOs RD/RA, Preliminary Closeout Report (for OU#2), Performance Standard Verification Plan (PSVP), Performance Evaluation Plan (PEP), Operations and Maintenance (O&M) Plan, Quarterly Bioassay Reports, Annual Operations Reports, and Monthly Progress Reports.

Project Management

In July 1999, NWI replaced MEC as the Respondent's Project Coordinator for the Site and Montgomery Watson replaced CRA as the consulting engineer for the Site.

Deficiencies and Recommendations

No deficiencies of the remedy have been identified. It is recommended that the annual sampling event, that currently occurs during the second quarter, be changed to occur during the first quarter.

Next Review

The next Five-Year Review will be required in 2005, five years from the completion date (i.e., signature date) of this Five-Year Review Report.

Protectiveness Statement

The remedial actions for OU#1 and OU#2 are properly operating to be protective of human health and the environment.